Research Article

QMH (Quantifying Mental Health) Key Technologies

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In order to understand the chaotic nature of mental health, a forensic simulation of the mental health system is under development. This paper discusses the requirements and key technologies based on Ontological Engineering. Ontological engineering is expected to provide a foundation of so-called Content-Directed Artificial Intelligence which relies on the development of an *integrated World Knowledge DataBase* (*WKDB)* necessary for the understanding of mental health. Artifical Intelligence is based on the design of it's creator/s and as such unknowingly "bias creep" can easily be imbedded into the design of its WKDB[1].

Mental health techniques are required in order to develop a mitigation plan for the alleviation fo pain which is of both mental as well as physical. This paper address the requirements for the mitigation of mental pain. Specifically anxiety and depression are the most common problems, with around 1 in 10 people affected at any one time. What is the cause of mental health problems problems and what is it's affect? Anxiety and depression can be severe and long-lasting and have a big impact on people's ability to get on with life. Predictions of beliefs and thoughts (good and bad) are brain outputs due to the measured vision, hearing inputs, and autonomic activation of one's residual WKDB.

Currently our QMH Forensic Simulator yields potential target pharmaceutical parameters which could be used in the design of experimental medication for mental health patients. Additional medical producals could then be designed for use in future mental health clinical trials.

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Overview

Cause and Effect

https://media1.tenor.com/images/dad2c576db235144699941a18c7900b9/tenor.gif?itemid=17537593

As stated in [1], "*There are three challenges health systems will face in addressing algorithmic bias. First, lack of a clear definitions and standard of "fairness", second, insufficient contextual specificity, and third, the "black-box* [2]*" nature of algorithms.*".

These challenges must be addressed in order for problems encountered in the maintenance

of **good vs bad** mental-health can be achieved.

How can "one" change the world of mental health? Potentially by the use of forensic simulation[1] as illustrated in **Figure 1.** Behavioral commitment to the values of **Belief, Love,** and **Hope** are expressed in terms of their respective numerical output values. These values are compared to their opposites of **Knowledge, Hate,** and **Despair.** The mimimization of the error between these value sets are brought about Ontological Engineering's: a) Design and it's b) Signal Processing perspectives as shown in **Figure 2** when aided by the measurement of one's **LOS** (**L**ine **O**f **S**ight) vector and the Albus/Mystel **EOTB**(**E**ye **O**f **T**he **B**eholder) of **Figures 3** and **4.**

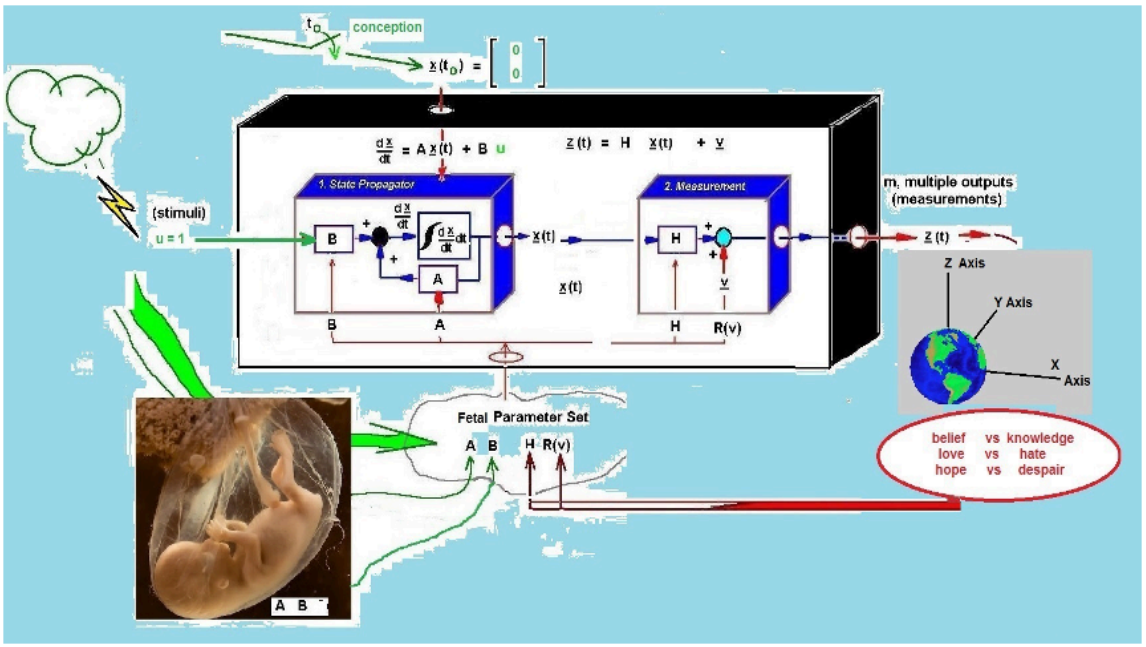

Figure 1. The Variables of Spiritual and Secular Space

$$\text{Error} = \begin{cases} \text{Signal Processing} - \text{Design} \\ \text{Design} - \text{Signal Processing} \end{cases}$$

$$\underbrace{\text{Design}}_{\text{BRAIN}} - \underbrace{\text{Signal Processing}}_{\text{LOS}}$$

$$(\ \text{left} \quad \text{vs} \quad \text{right}\ )$$

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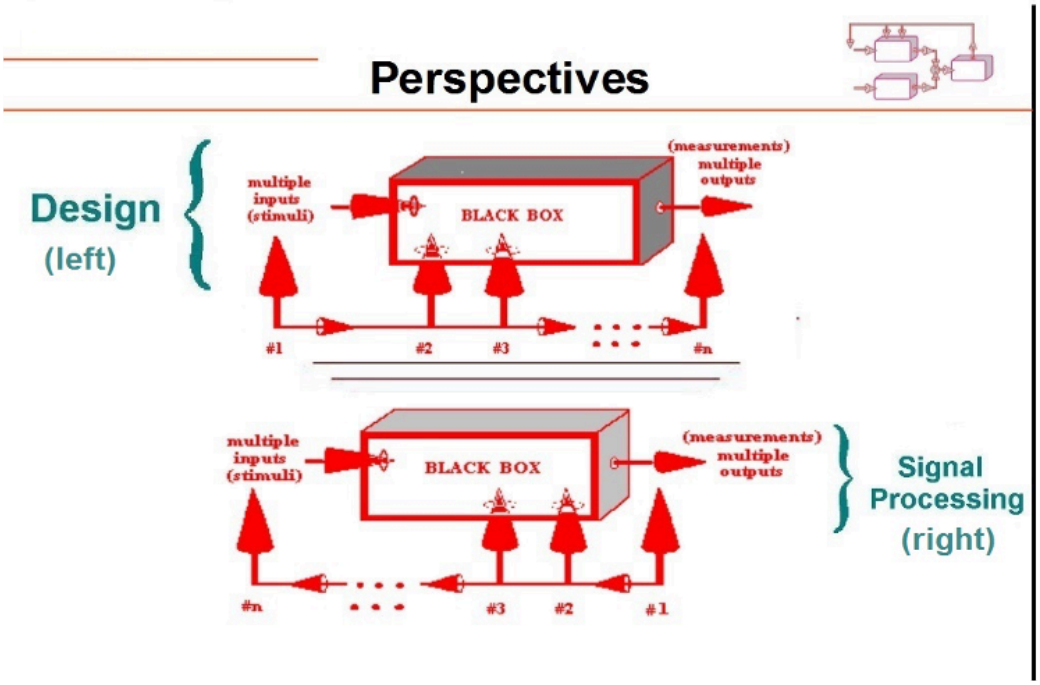

Figure 2. Ontological Engineering Perspectives

Stakeholders, practitioners, and designer's of mental health systems design and deployment typically consist of people being governed by their *sense of morality which is equivalent to answering "The Primary Question of Ethics: How Shall I Live?"* and requres understanding of the correlation of Ethics, Economics and Education as measured from the **m** observer's[2] the **LOS** (**L**ine **O**f **S**ight) [3] as illustrated in:

- **Figure 3**,
- the *output* of **Figure 1,** and
- **Figure 4** - *life's* **EOTB** *homeostatis design* [4]

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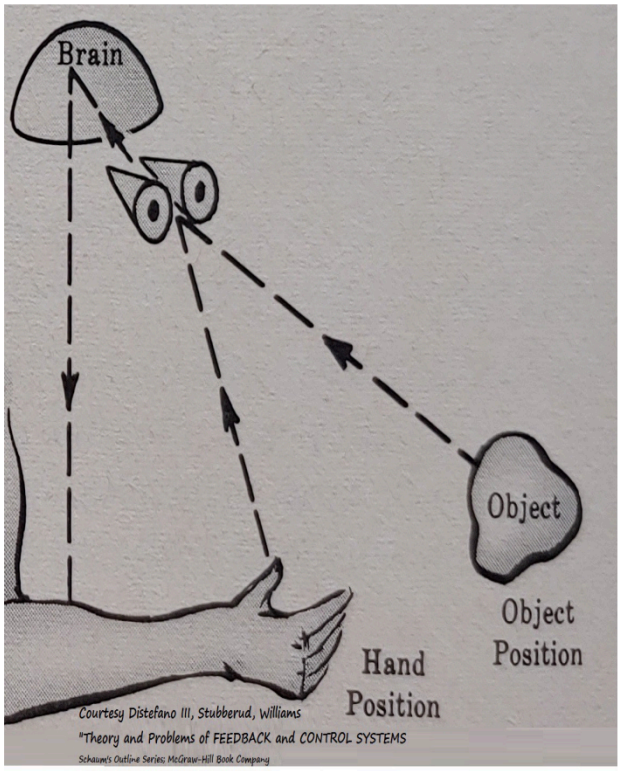
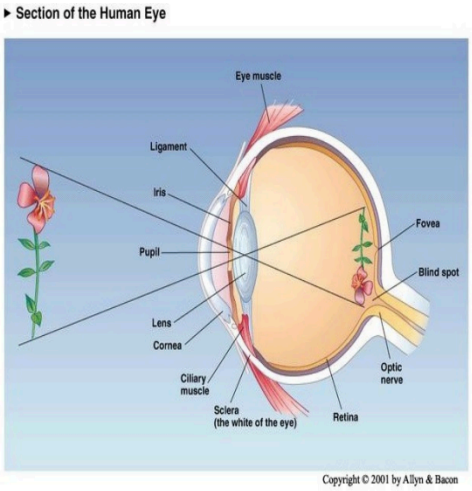




Mental Instability from inverse measurement system -- visual to mental transition broken? Law of Optics satisfied it is the same as Optical Communication. For example: Use of Lens performs the necessary integration funtion of analytics input to output via the convolution of impulse function with input function.

a) Homeostasis Hand Control via LOS **b) External vs Internal Info Transfer**

Figure 3. LOS (Line Of Sight) **via Feedback and Control of Systems**

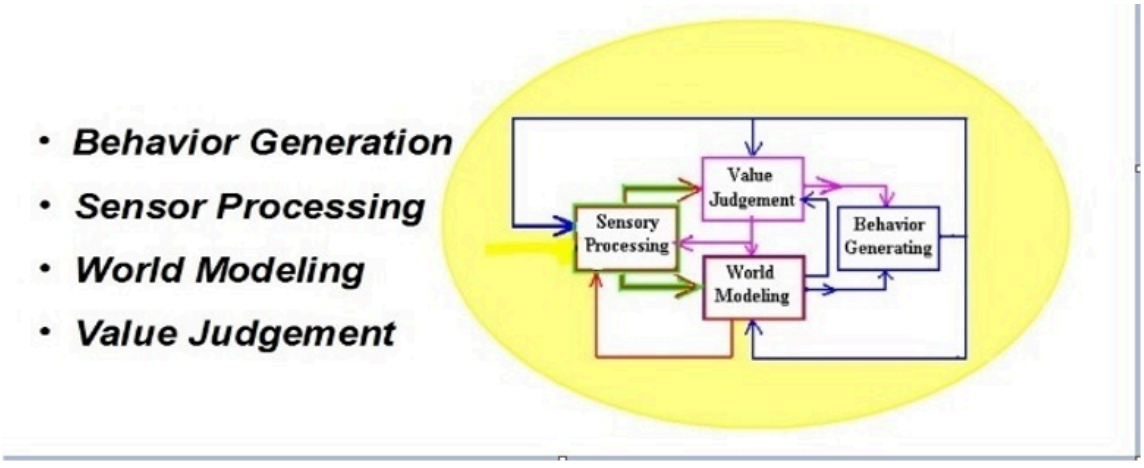
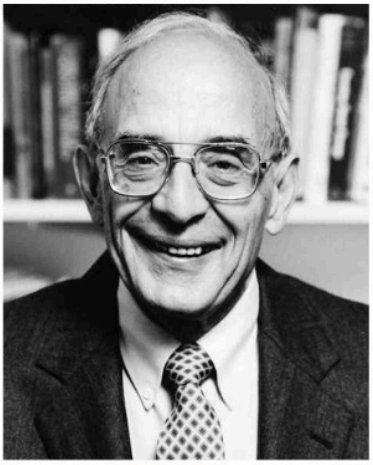


Figure 4. Albus/Mystel [4] **EOTB Homeostasis Architecture**

(Feedforward and Feedback Signal Flow)

Intelligent system design involves the notion of *planning* which can be evaluated by the signal processing of life's homeostasis loops. The *stability of these loops* are controled by the brain's internal error signal as generated by it's feedforward and feedback neurological current flow. For example: Consider the thought process involved in the *Education of others to problem solve:*

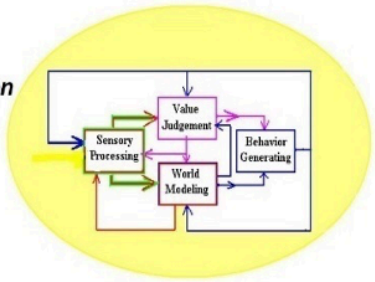
First, most people define learning too narrowly as mere "problem solving," so they focus on identifying and correcting errors in the external environment. Solving problems is important. But if learning is to persist, managers and employees must also look inward. They need to reflect critically on their own behavior, identify the ways they often inadvertently contribute to the organization's problems, and then change how they act. In particular, they must learn how the very way they go about defining and solving problems can be a source of problems in its own right.



Chris Argyris
James Bryant Conant Professor
Harvard Business School

Albus/Mystel EOTB

- Behavior Generation
- Sensor Processing
- World Modeling
- Value Judgement



"Unaddressed mental health problems can have a negative influence on homelessness, poverty, employment, safety, and the local economy. They may impact the productivity of local businesses and health care costs, impede the ability of children and youth to succeed in school, and lead to family and community disruption."[5]. *Hence in order to mitigate of mental health problems it's stakeholders, practitioners, and educators, must have a mimimal understanding of control theory for successful implementation of* ***QMH.***

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A. QMH Mental-Health System Requirements

1. **Design**
   - **Shall support cooperative management of educational platforms and their associated measurement sensor assets such that:**

     it's WKDB (World Knowledge DataBase) be based on

     - ***intelligent system design***

that will provide

- *plan generation*

that will be

- *evaluated*

with respect to its

- *effectiveness*

- **Shall provide the mechanism that will provide**

  - feedback

  in the planning process in order to optimize performance

2. **Satisfy The Architecture Design Definitions:**

- Architecture: the structure of components, their relationships, and principles of design, including the assignment of functions to subsystems and the specification of the interfaces between subsystemsand principles of design, including the assignment of functions
- *Reference model architecture: an architecture in which the entire collection of functions, entities, events, relationships, and information flow involved in interactions between and within subsystems are defined and modeled to be:*
  - ***Design Elements of Reference Model Architecture***

    - Knowledge Database - World Modeling

    - Sensory Processing - Evaluation/Optimization

3. **QMH Tool Box Educational Notions To Be Accessed[3]:**

- ***- ontological engineering - knowledge databases***

  - optimization of performance metrics - data fusion

  - adaptive processing/reasoning - sensor processing

  ***- model based reference systems* - data mining**

  ***- estimation, identification, control* - fuzzy logic**

  - qualitative reasoning - image processing

  ***- modeling methodologies* - communication theory**

  - cognitive reasoning

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B. Cause and Effect of QMH:

The analysis of

high level planning **based on human reasoning.**

considers for example: how the prefrontal cortex uses

. task knowledge

to hypothesis

tentative plans

which are submitted to the dorsolateral prefrontal cortex which

simulates

the plan (via the imagination) in order to

predict plan results

which are then

evaluated

via the subcortical limbic system

The neurological signal flow of this process is illustrated in the simplified diagram of **Figure 5.**

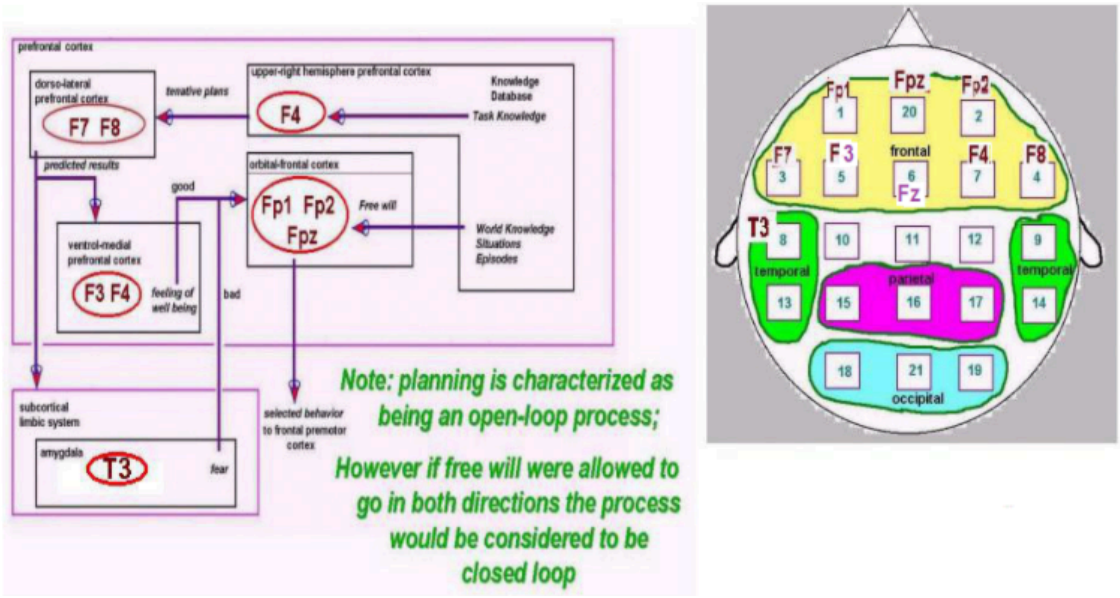

Figure 5. A Simplified Flow Diagram Of The Brain And It's Measured EEGHigh-level Planning System[4]

Recall 1) architecture requirement demands that the structure of planning must be achieved via the use of feedback, and 2) reference model architecture is based on modeling theory satisfying the error

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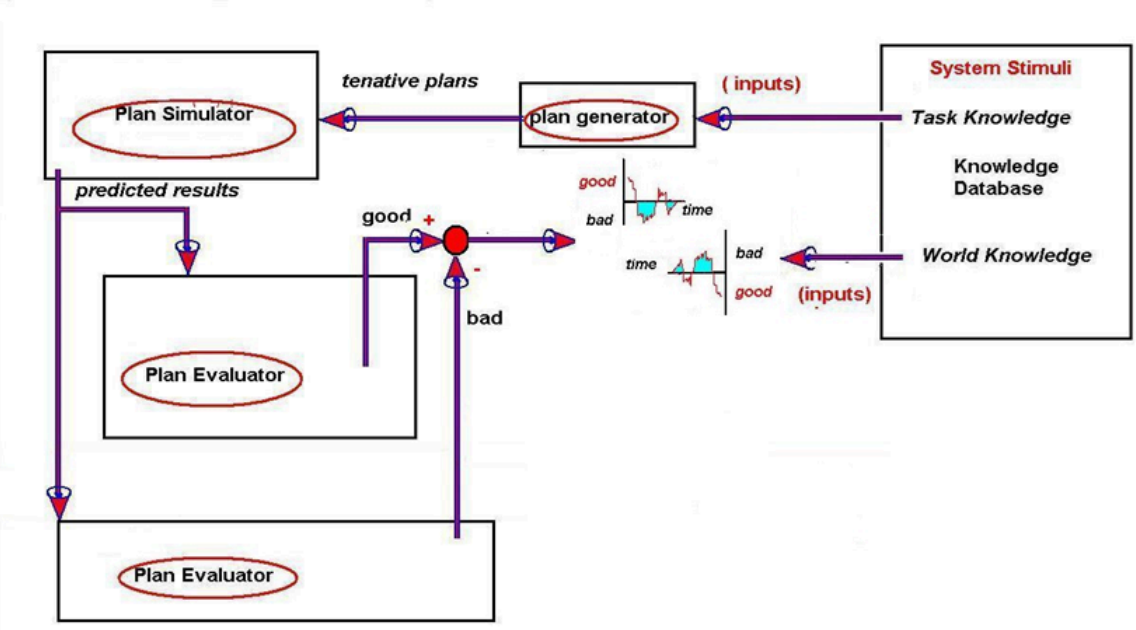
optimization of the right to left difference. Ontological models exhibit two types of structure, either they employ no feedback, i.e, the employ homeostasis control via the methodology of - ***Open-Loop-Control*** [6] [7]



Good vs Bad

Figure 6. Open-Loop-Control of Systematic Homeostasis [8]

or they incomporate error feedback (**Figure 7)** by employment of - ***Closed-Loop-Control***

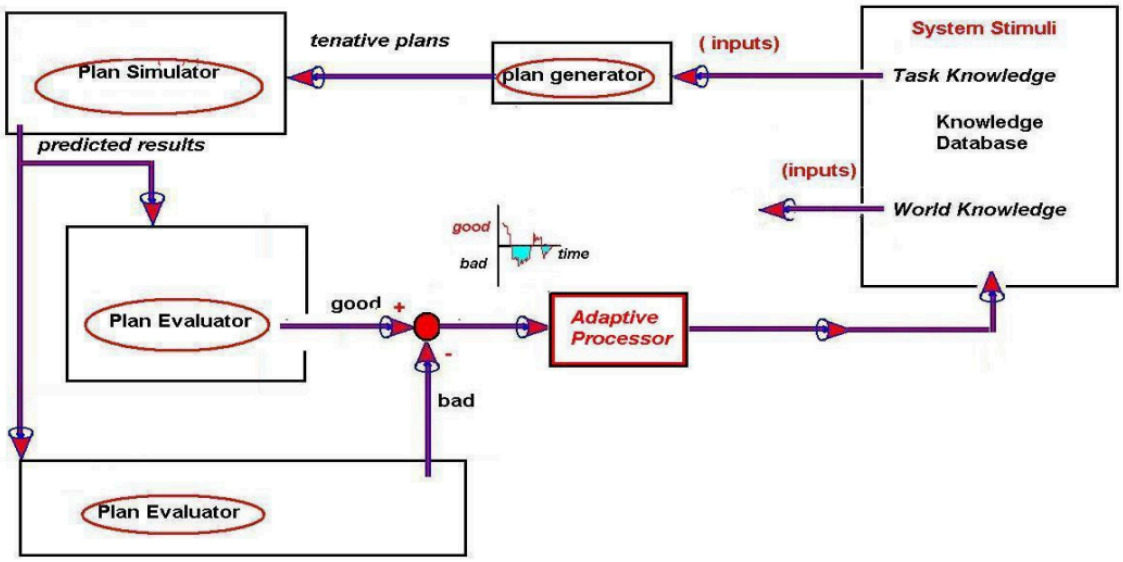


Figure 7. Closed-Loop-Control via the Adaptive Processor Yielding Systematic Homeostasis Stability - see Figure 6

The organic sensor (the brain) provides the *good vs bad* measurement (**Figure 8)** and as such yields a contradition of *"thought over a given time-frame"* - **Figure 9.**

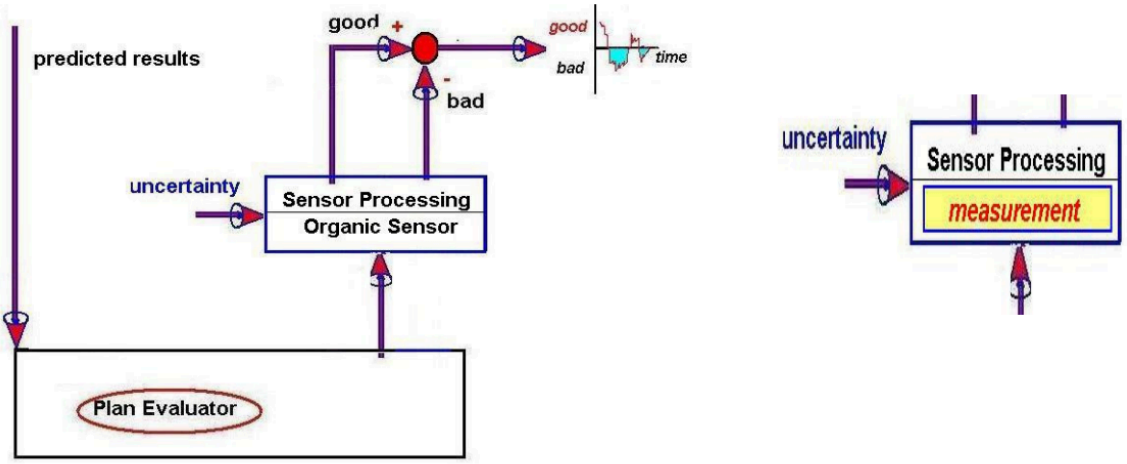


Figure 8. OLM Organic Sensor Signal Processing

task knowledge is dependent upon the problem TBS (To Be Solved)

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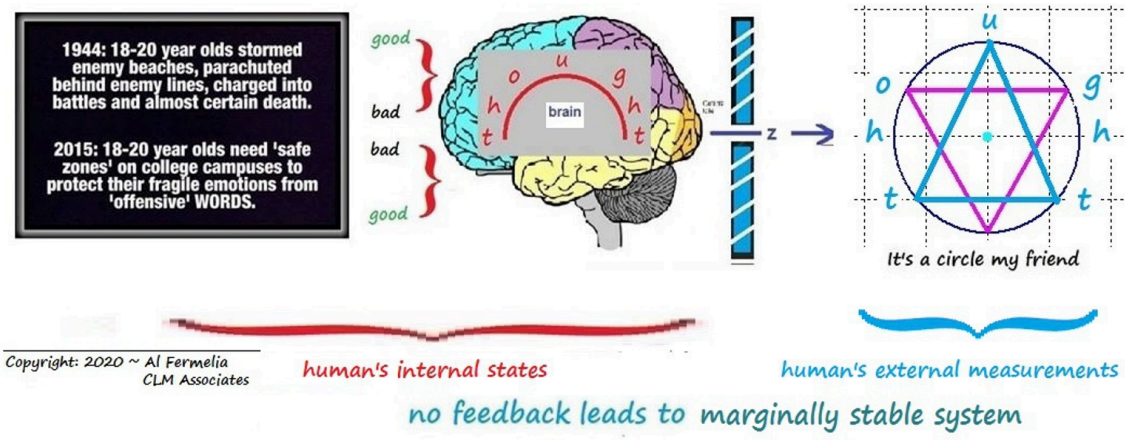

Figure 9. OLM Organic Sensor Changing Thought

C. Results and Conclusions

Forensic circumstantial evidence can be presented by consideration of the following two examples:

<u>Example 1: Good vs Bad.</u> Consider the thought process of **Figure 10.** As illustrated the thought process of the brain[5] is producing good and bad thoughts from the "Sensor Processing" of a scene obtainable from the **plan evaluator** of **Figure 11**.

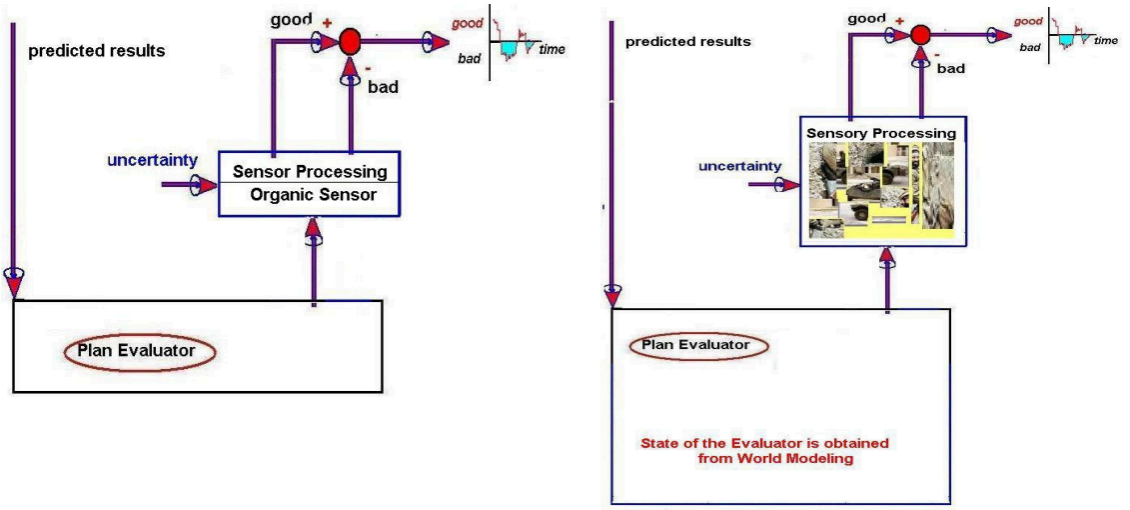

Figure 10. Measurement Of Thought

Is it good or bad?

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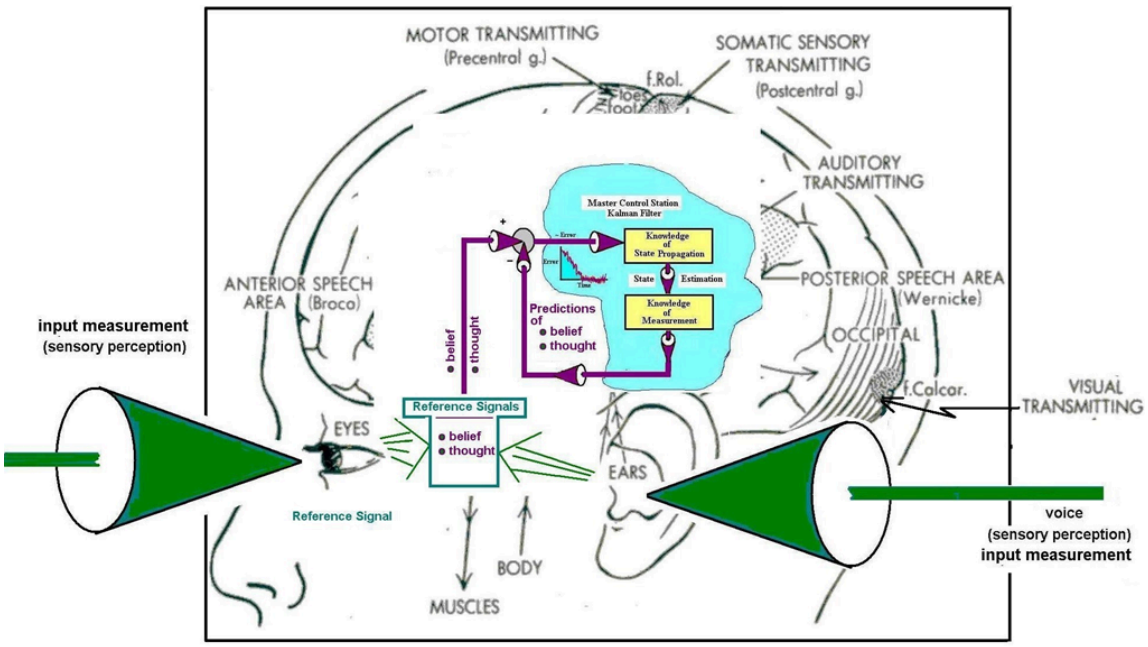

Figure 11. The Brain Has a Mind of It's Own Referenced On Its Measurement Systems Of Belief and Thought Errors Utilizing the WKDB

Example 2: Anxiety. A second example is the "anxiety" associated with the current Corona epidemic as illustated by **Figure 12**

Example 2: Anxiety ~ Is it or Isn't it? ~

Corona Virus

Question: What is the Primary Problem?

Answer: Measurement of Anxiety !

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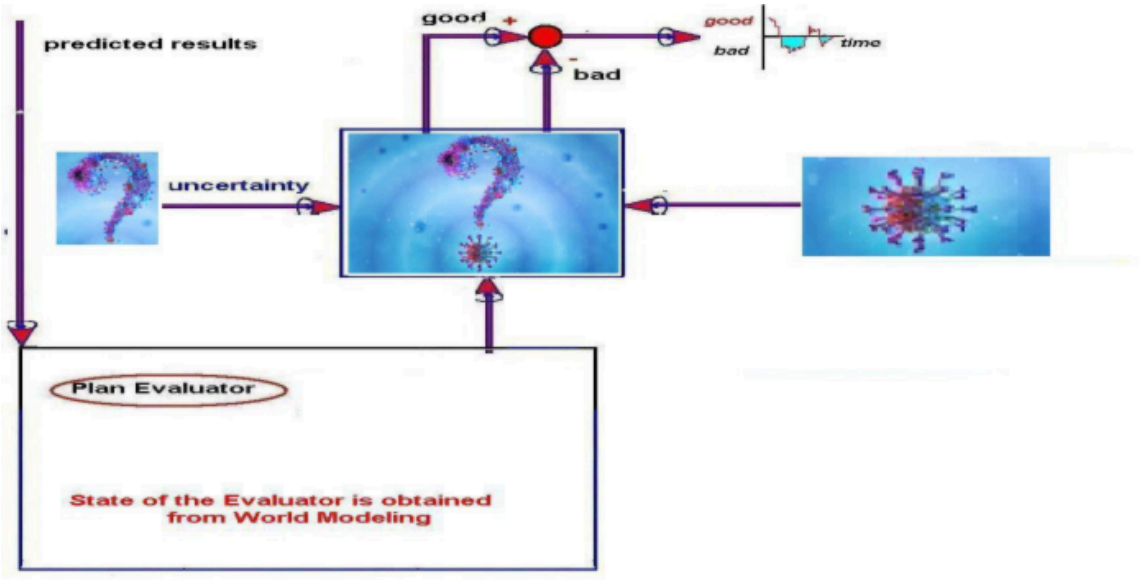

Figure 12. Anxiety Example

As such the following result is obtainable:

1. **Mitigation of Pain (Mental and Physical):** ***Predictions of beliefs and thoughts (good and bad) are brain outputs due to the measured vision, hearing inputs, and autonomic activation of one's residual WKDB.***

   The problem addressed by Example 2 produces the following question and answer

   Question : How Can Anxiety Be Mitigated?

   Answer : By Implementation Of

   Adaptive Processor Design

   - Design is predicated on the answer to the following questions:
     1. What variables in the Knowledge Database does the Adaptive Processor modify?
     2. Does it add variables that do not exist?
     3. What is the mechanism for adapting the Knowledge Database
     4. What is the Knowledge Database comprised of?

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Insight to the answer to these questions will be obtained by detailing the properties of a reference model architecture for an intelligent system.

Properties of a reference model architecture for an intelligent system

- **Defines the function elements, interfaces, and information flow within and between intelligent systems**
- **Specifies the informational units and data models for both static (longterm) and dynamic (short-term) representations of knowledge necessary to describe the environment and intelligent systems operating within it.**
- **Specifies processes by which goals are selected, plans are generated, tasks are decomposed, subtasks are scheduled, and feedback is incorporated into control so that both deliberative and reactive behaviors can be combined and coordinated into a single integrated system.**
- **Specifies processes by which signals from sensors are transformed into knowledge of situations and relationships.**
- **Specifies symbolic and iconic representations for knowledge of objects, events, relationships, and situations in space and time, including semantic, pragmatic, and causal relationships in data structures that can support reasoning, decision making, and control.**
- **Specifies how knowledge can be acquired (learned), stored (remembered), and retrieved (recalled).**
- **Specifies how values can be represented and used to compute cost, benefit, risk, and uncertainty for evaluating plans for the future and assessing results of past behavioral choices**
- **Specifies the timing of processes and temporal relationships between functional elements**

Validation of the ***Adaptive Processor Design*** requires the integration of ***BehaviorGeneration, Sensor Processing, World Modeling,*** and ***Value Judgement*** as illustrated by **Figure 13.**

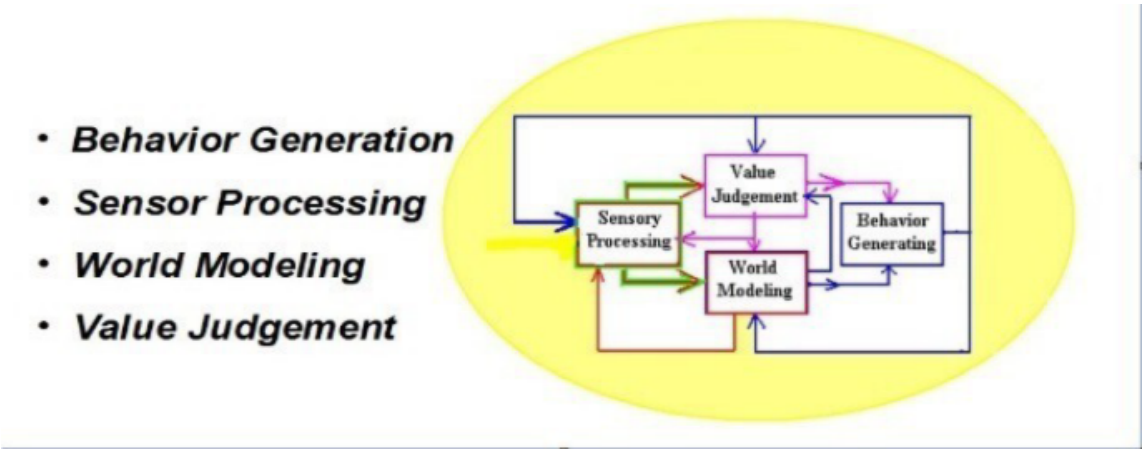

Figure 13. Reference model architecture subsystem functional elements

Upon validating the adaptive processor design via the application of ontological engineering design the pain (refered to on page 9) associated with many health problems may be mitigated. For example: The Coronal Virus of **Figure 14**.

"Good Bye Rosie, Queen of Corona Down by the School Yard"

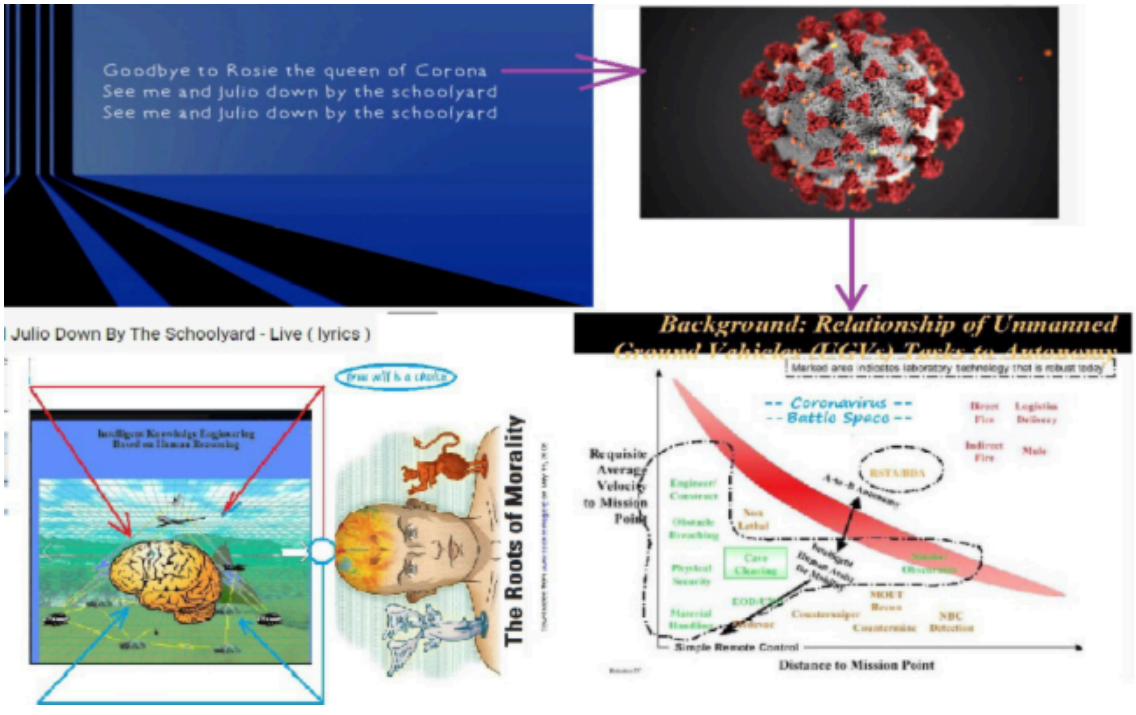

Figure 14. Ontological Engineering Applications via CLM ~ see [2][9]

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2. **Cause And Efect** of a system can be quantified using **CLM**[6]. This is accomplished by: **a)** the population of its Classification Set **(CS), b)** solving the differential equations which govern its dynamics, and c) the interactions of it's independent subsystems. For example: In **Figure 1,** the **stimuli (u)** represents the **cause or controlled input** to the system. This input acts on the system's initial internal **state**[7] **variables (x)** whose motion satisfys the **n** set of **1st order linear differential equations** whose coefficients consist of it's systems internal static variables [6][10][11]:
    1. **A, the n x n Dynamics Matrix,** and
    2. **B, the n x q Control Matrix.**

$$\frac{d\underline{x}}{dt} = A\,\underline{x} + B\,\underline{u} \qquad \underline{z} = H\,\underline{x}$$

$\underline{x}$ = n x 1 state vector
A = n x n dynamics matrix
B = n x q control matrix
$\underline{u}$ = q x 1 control vector

$\underline{z}$ = m x 1 measurement vector
H = m x n measurement matrix

Table 1. System Governing Equations

Where the structure of the **A** dynamics and the **B** control matrices as well as the measurment **H** matrix are populated by the values from **Table 2**

$$A = \begin{pmatrix} -\sigma & \omega_d \\ \omega_d & -\sigma \end{pmatrix} \quad B = \begin{pmatrix} 0 \\ \omega_n^2 / \omega_d \end{pmatrix} \quad H = \begin{pmatrix} 1 & 0 \end{pmatrix}$$

Dynamics Matrix Control Matrix Measurement Matrix

where the critical pharmaceutical parameters are given in the matrices, **A, B,** and **H** with (see **Table 2** and **Figure 20)**

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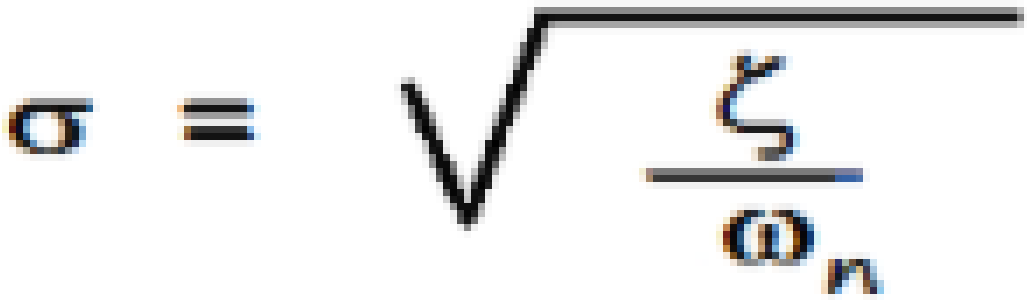


The **Effect/Output** of the system is quantified by the **m** measurements **z** of the behaviorial actions due to the **thought process.**

3. **As an exhibit of circumstantial evidence of the value of the Forensic Simulator, consider the EEG prefrontal cortex measurements of the human brain (F3, F4, T3). Illustrated in Figure 15.** These are actual EEG tests of a patient recorded by Dr. Lavar Best head of the Craig Hospital neurological department [12].

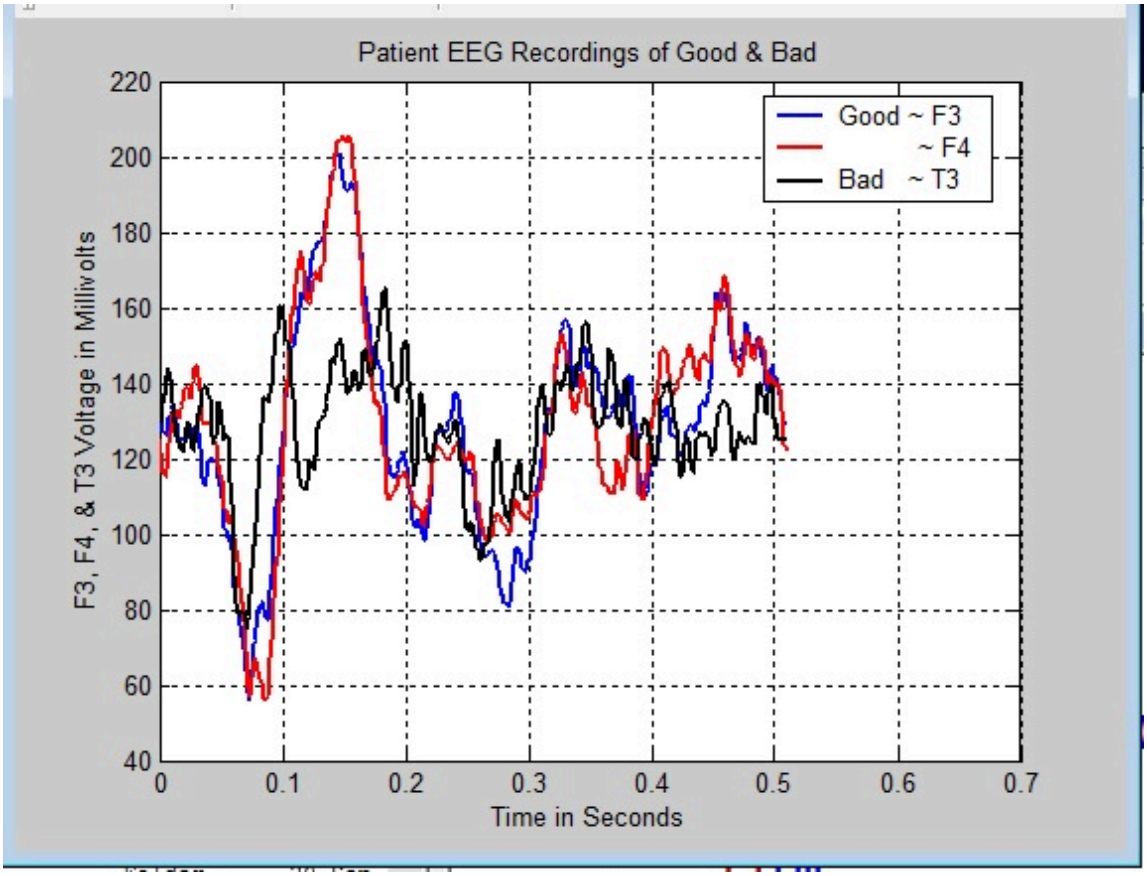
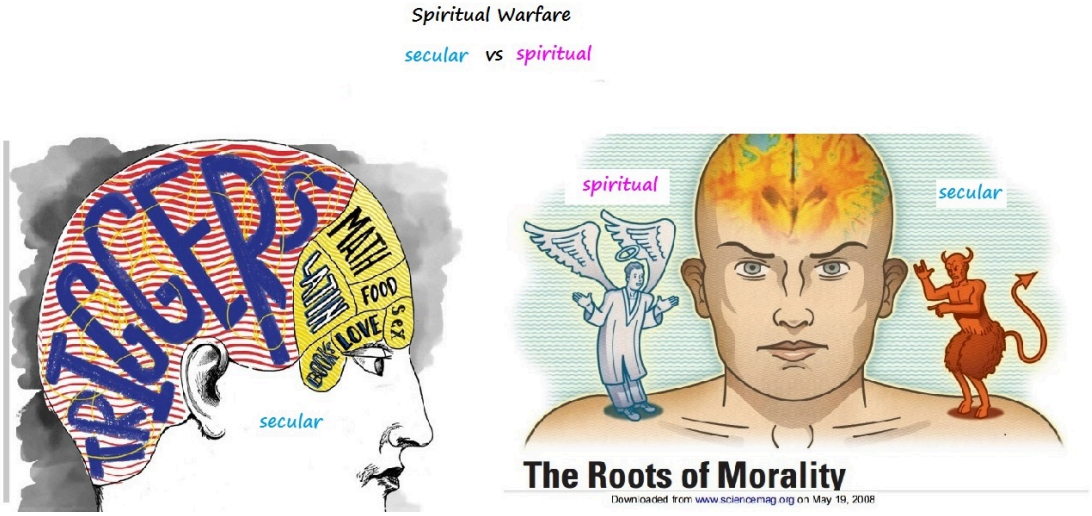


Figure 15. Patients Prefrontal Cortex Measurements

Figure 15 povides the specific measurements first introduced by **Figure 5,** described analytically by **Table 1** and quantified by the values of **Table 2.**

A simplified overview of the entire **brain thought process** beginning with it's **neurological trigger inputs** resulting in **behavioral generation management** as an **output** is illustrated in **Figures 16** and **Figure 17.**



a) [left] The Triggers of Thought

b) [right] Actions of ThoughtHemispheres of Thought

Figure 16. The Brain: Trigger Zone Acts As Inputs to the Axon Zone

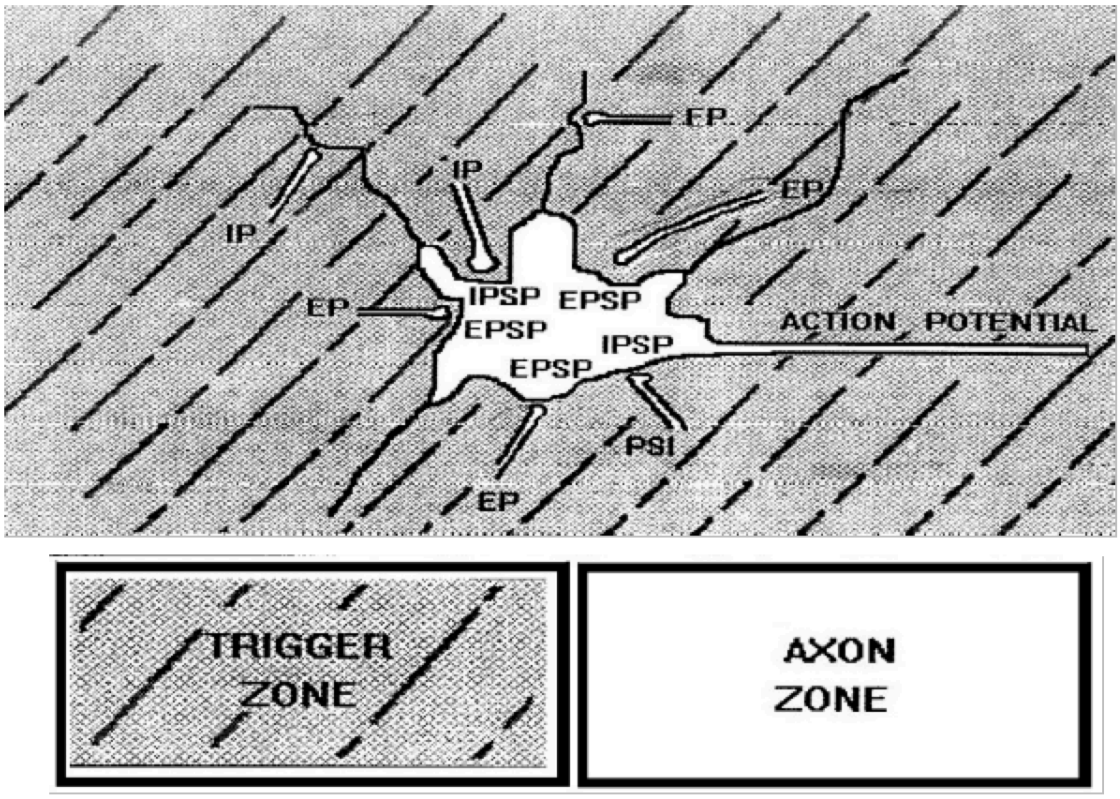


Figure 17. Brain: Trigger and Axon Zones

Once the **WKDB** [8] has been obtained by applying the ontological engineering **SID** (**S**ystem **Id**entification) algorithm [12] yielding the quantitative values as given in **Table 2,** the governing equations of **Table 1** where solved in MATLAB. The trigger zone simulation of the three (F3, T3, and F4) yield a solution to the governing single 1st order differential equations corresponding to the respective left and right EEG's. The results produced the Trigger Zone output (**Figure 18 a)** which are the inputs to the Axon Zone yielding the internal behavioral 3 dimensional responses of **Figures 18 b).**

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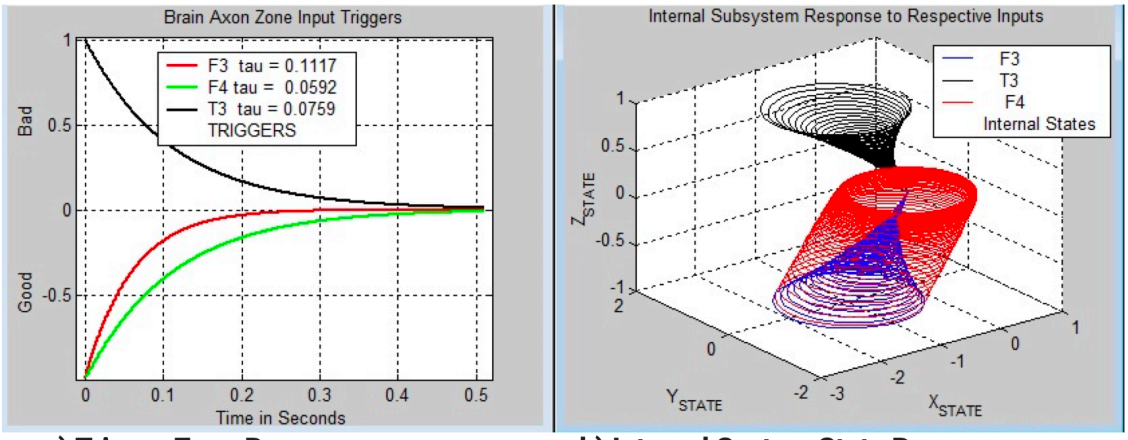
Initial THOUGHT WKDB

EEG		Fequencies damped ω_d	Fequencies natural ω_n	Damping factor ζ	Input time constant τ
	Hz	rad/sec	rad/sec	unitless	seconds
F3	230.34	1447.29	1469.24	0.1722	0.1117
T3	157.94	992.35	1450.54	0.7294	0.0759
F4	211.90	1331.41	1331.41	0.0001	0.0592

Axon Trigger

Classification Set Internal State Constituents

Table 2. SID Algorithm Solution Provides Table 1 Quantitative Values



a) Trigger Zone Response to Initial Conditions
F3 = -1; T3 = 1; F4 = -1

b) Internal System State Response of Left and Right EEG States
Axon => X Y
Trigger Output => Z

Figure 18. Time and Space Cause and Effect

The brain's **internal effect (it's OLM states** [6][2][7] due to the systems **cause inputs** for it's respective **LEFT** and **RIGHT** hemispheres is evidenced by the time response illustrations of **Figure 19**.

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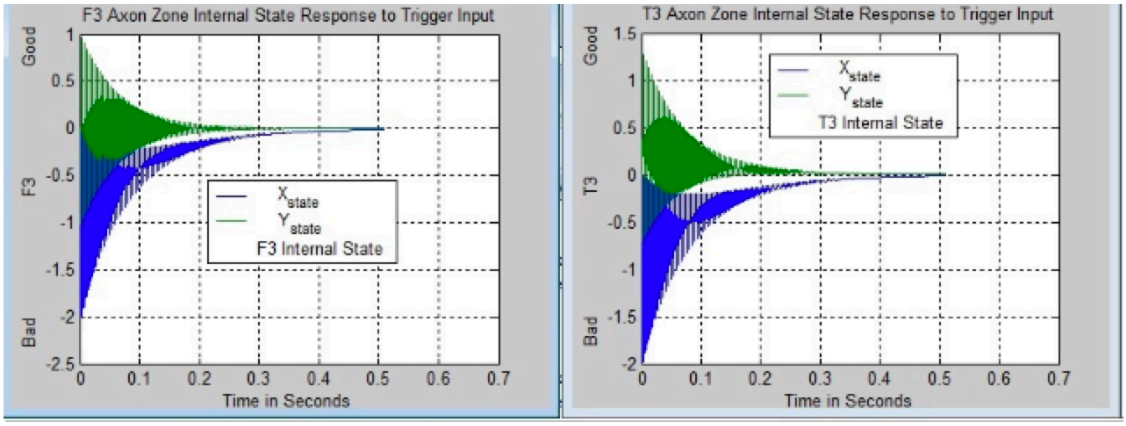
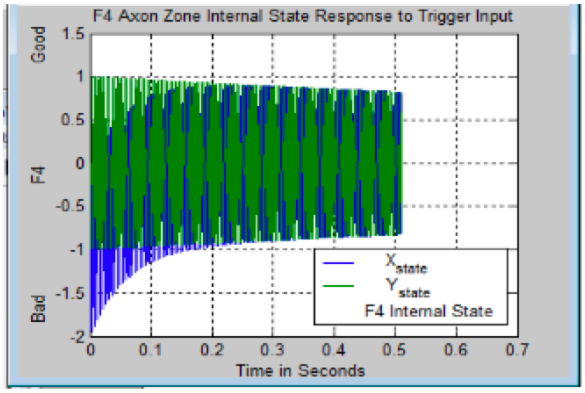


LEFT Hemisphere

a) F3 Internal State Time Effect **b) T3 Internal State Time Effect**



RIGHT Hemisphere

c) F4 Internal State Time Effect

Figure 19. Internal Brain Hemisphere Effects

4. **As Quantitative EEG characteristics provide the design requirements of pharmaceutical trials.** The CLM SID algorithm was used to obtain the respective WKDB's for an individual brain's 21 EEG's **(Figure 20)** and as such provides circumstantial evidence indicative of internal behaviorial output.

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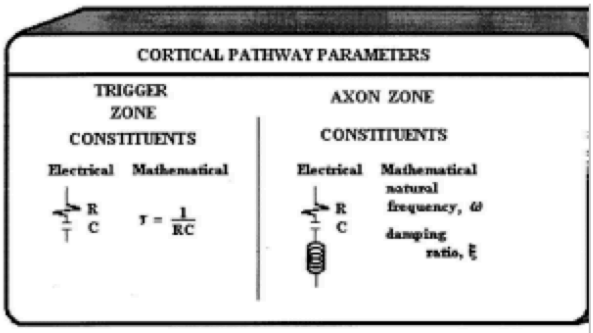
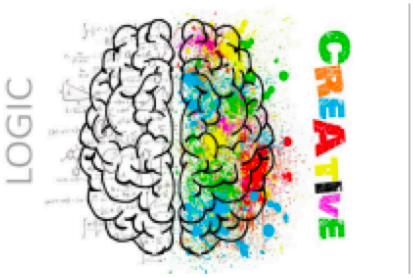


NEURAL PATHWAY CHARACTERISTICS

ANALYZER Results for EEG Data Taken at 21 Cranial Locations which Recorded Frontal, Occipital, Temporal, and Parietal Electrical Activity

PIXEL #	COEFFICIENTS a	b	c	AXON ZONE natural frequency ω_n	damping ratio ξ	TRIGGER ZONE time constant τ
1.0000	0.4986	-1.0000	1.4986	0.7071	0.3546	0.9971
2.0000	0.5121	-0.5604	1.0242	0.7215	0.0280	0.9837
3.0000	0.4953	-1.0094	1.5047	0.7072	0.3636	0.9905
4.0000	0.1995	-0.5985	1.3964	0.4474	0.4466	0.9968
5.0000	0.4980	-1.0000	1.4980	0.7071	0.3550	0.9959
6.0000	0.5066	-0.5330	1.0132	0.7149	0.0154	0.9911
7.0000	0.3333	-0.3389	1.0000	0.5786	0.0036	0.9958
8.0000	0.4881	-1.0955	1.5836	0.7082	0.4309	0.9732
9.0000	0.1651	-0.5000	1.3302	0.4075	0.4121	0.9944
10.0000	0.9632	-1.0000	1.0184	0.9861	0.0141	0.9905
11.0000	0.3408	-0.3859	1.0225	0.5889	0.0337	0.9828
12.0000	0.2710	-0.3829	1.0839	0.5269	0.1024	0.9761
13.0000	0.2719	-0.3886	1.0876	0.5281	0.1066	0.9750
14.0000	0.2457	-0.7486	1.4972	0.4976	0.5072	0.9923
15.0000	0.4963	-1.0000	1.4963	0.7071	0.3562	0.9926
16.0000	0.9919	-1.0000	1.0000	0.9980	0.0020	0.9960
17.0000	0.9925	-1.0000	1.0000	0.9981	0.0019	0.9962
18.0000	0.9663	-1.9663	1.9888	0.9887	0.5058	0.9885
19.0000	0.4988	-1.0000	1.4988	0.7071	0.3544	0.9976
20.0000	0.0004	-0.9537	1.9481	0.9762	0.9976	0.0004
21.0000	0.9905	-1.9810	1.9810	1.0000	0.4952	0.9906



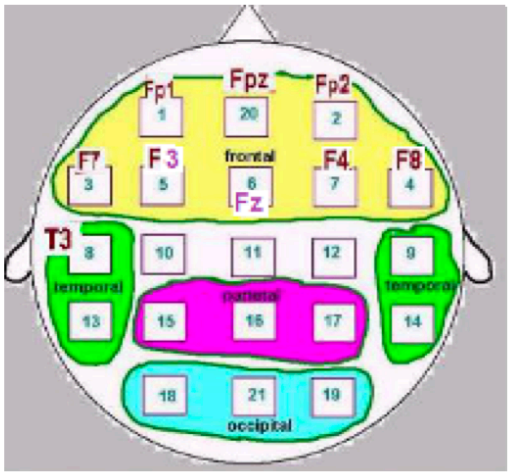


Figure 20. Right and Left Hemisphere of the Brain

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https://media1.tenor.com/images/dad2c576db235144699941a18c7900b9/tenor.gif?itemid=17537593

Footnotes

[1] Forensic Simulation: A model reference computer simulation designed to provide circumstance evidence of the occurrence of a mental-health event.

[2] The 3 observer's in this case are the independent stakeholders, practitioners, and designersmeasurements of Belief-Knowledge, Love-Hate, and Hope-Despair.

[3] Toolboxes highligted in red are discussed in this paper.

[4] See references [4][2]

[5] The brain is the organic sensor of Figure 10.

[6] For clarification of a system and its relationship to **CLM** see references [6][10][11][2][7]

[7] States of the system are internal – see [6] and [10]

[8] for the two left hemisphere EEG's (F3, T3) and the one right EEG (F4)

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Declarations

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